had been lost and the margin was regenerating. Text-fig. 85 illustrates how far this process had extended. It will be seen that the restitutive proliferations were most active along the free distal margin of the fin. Here several (four) eminences were present, each suggesting the pointed tip of the fin; there can, however, be no doubt as to which of these *is* the terminal one, since the skeleton of the fin can be followed into the lowest of these lappets. The case is evidently akin to one known to teratologists, for when certain areas in injured limbs of batrachians are stimulated, there appears polydactyly or polypody. It may therefore be worthy of record that a similar condition occurs in the lung-fish *Ceratodus*.

33. The Circulatory System of the Common Grass-Snake (*Tropidonotus natrix*). By CHAS. H. O'DONOGHUE, B.Sc., F.Z.S., Assistant to the Jodrell Professor of Zoology, University College, London.

[Received April 1, 1912: Read April 23, 1912.]

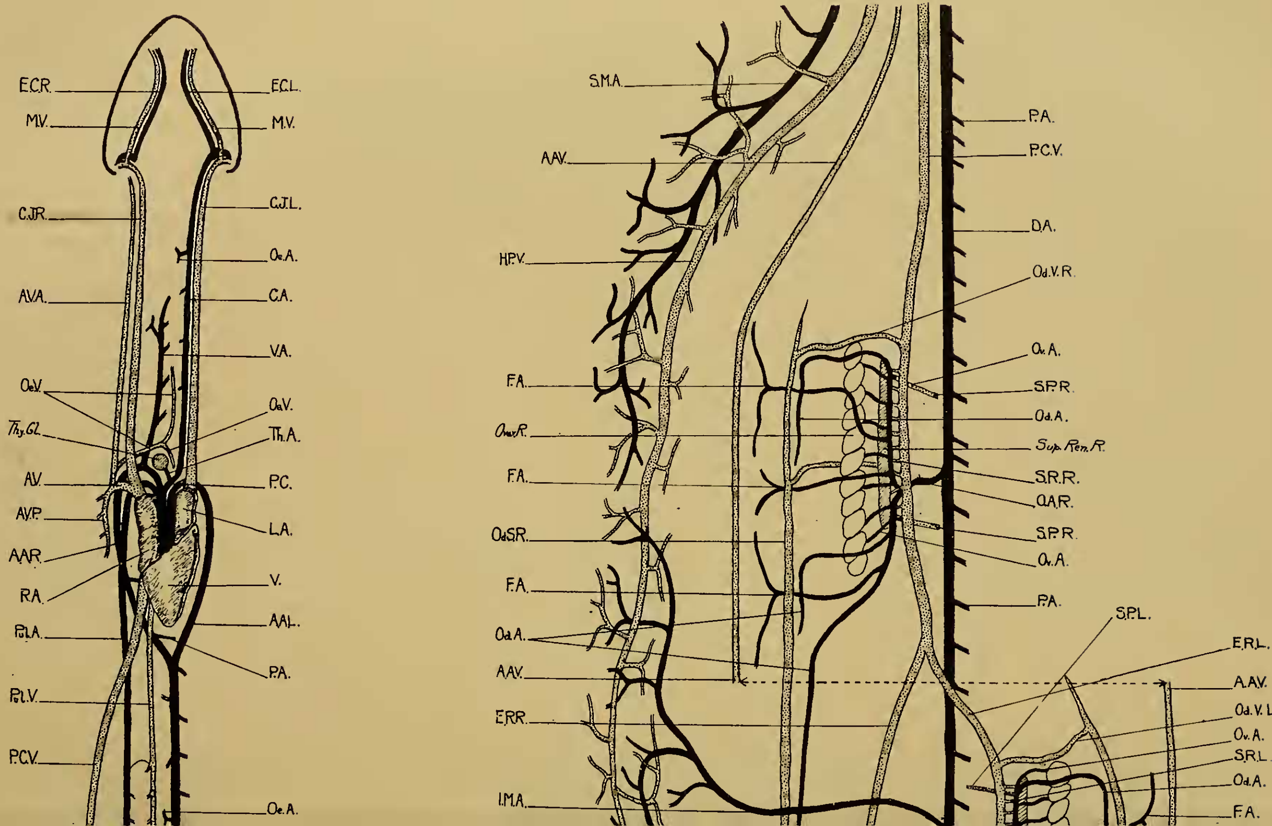
(Plates LXX.–LXXII. and Text-figures 86–91.)

INDEX.

I. INTRODUCTION.

Our knowledge of the circulatory system in snakes is far from exhaustive; indeed, we have only a complete account of the vessels in the Python by Hopkinson and Pancoat (**25**), and a later and a more full one by Jaquart (**26**), and in *Pelophilus madagascariensis* by Gadow *. Although *Tropidonotus natrix* is

* This is incorporated in the account given by Hoffmann (**23**).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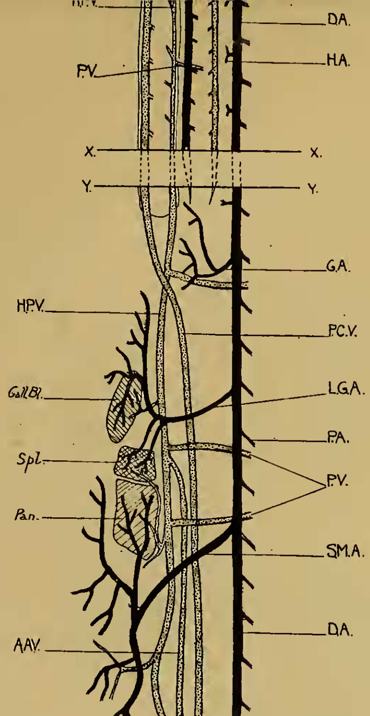

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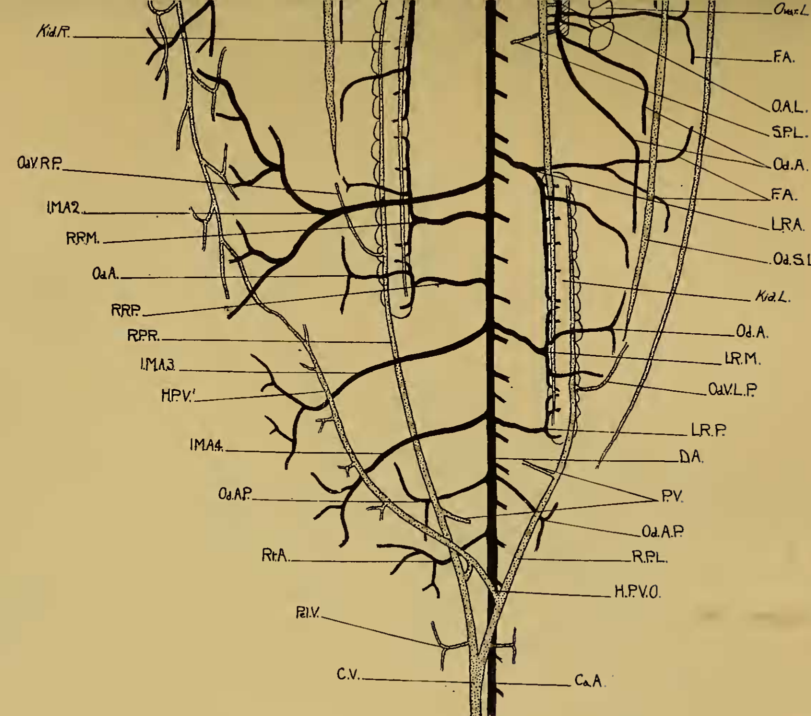

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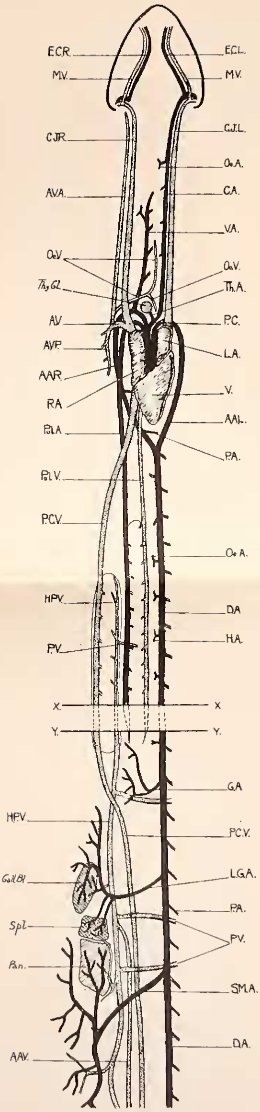

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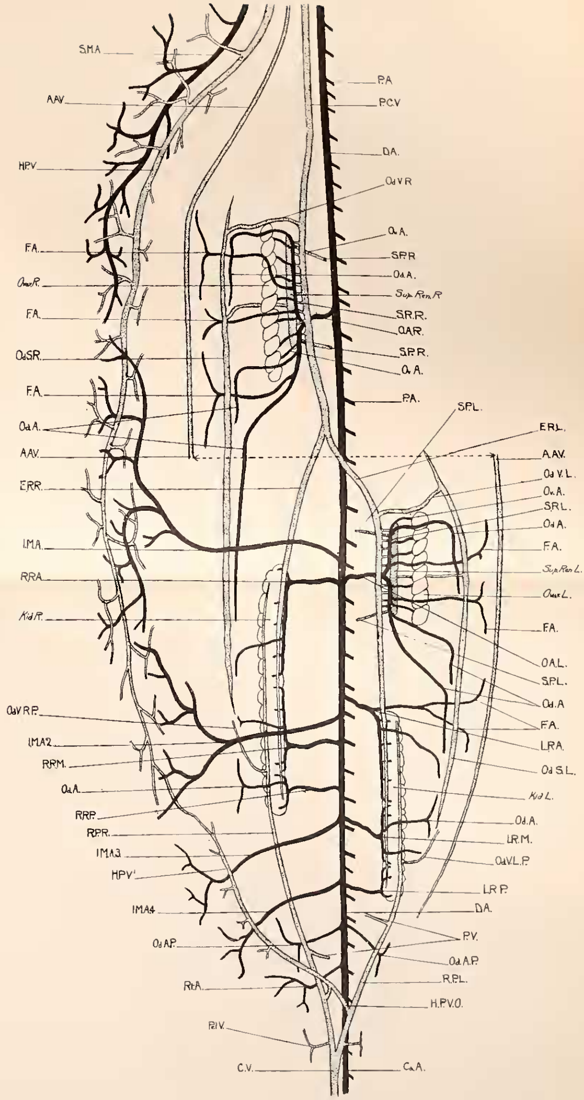

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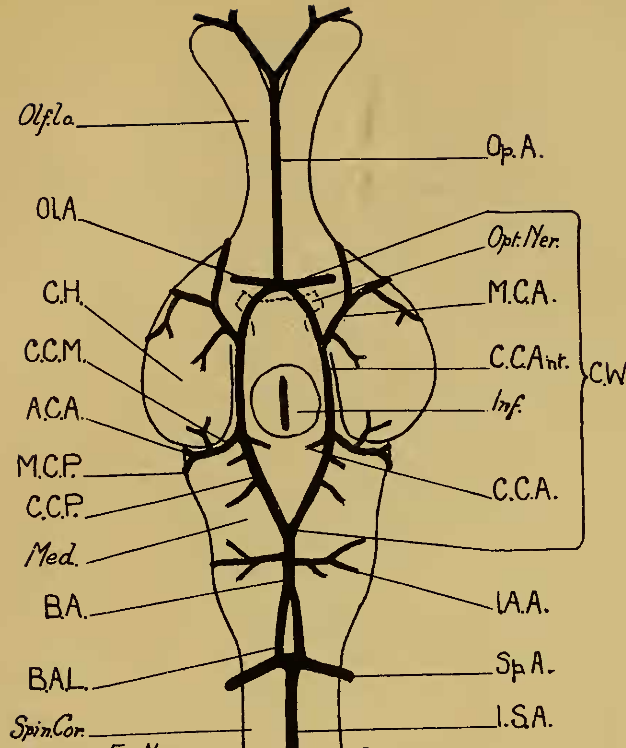

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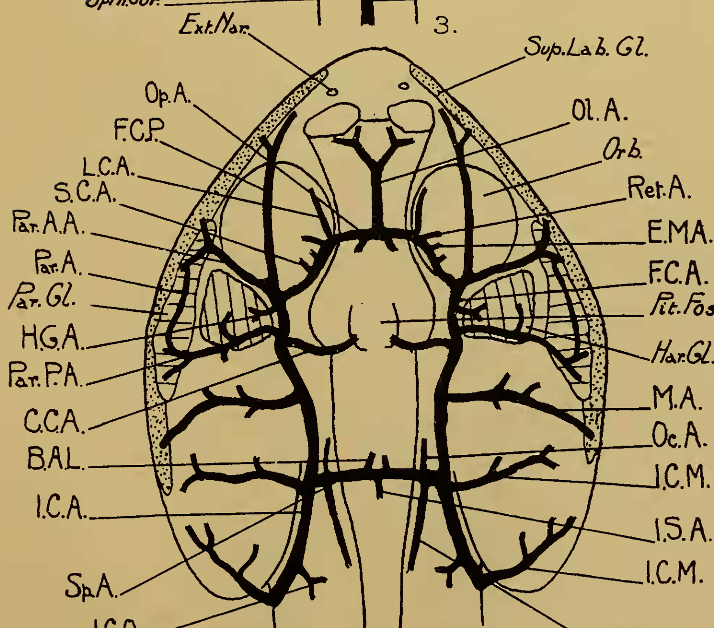

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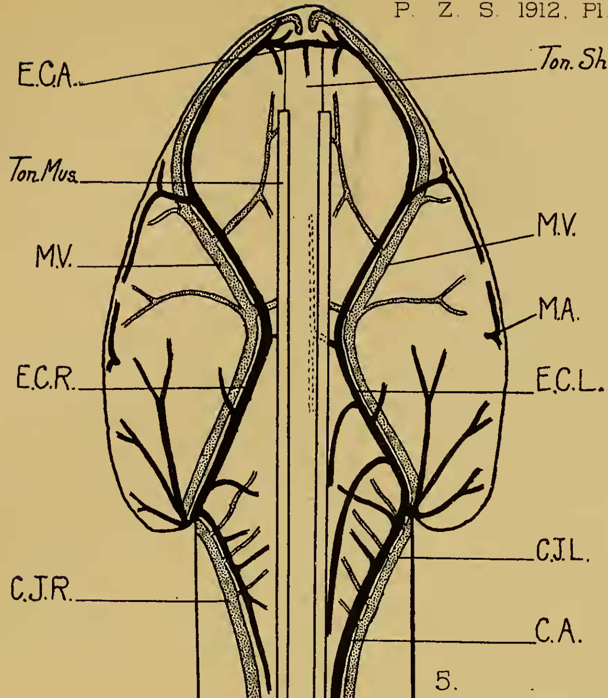
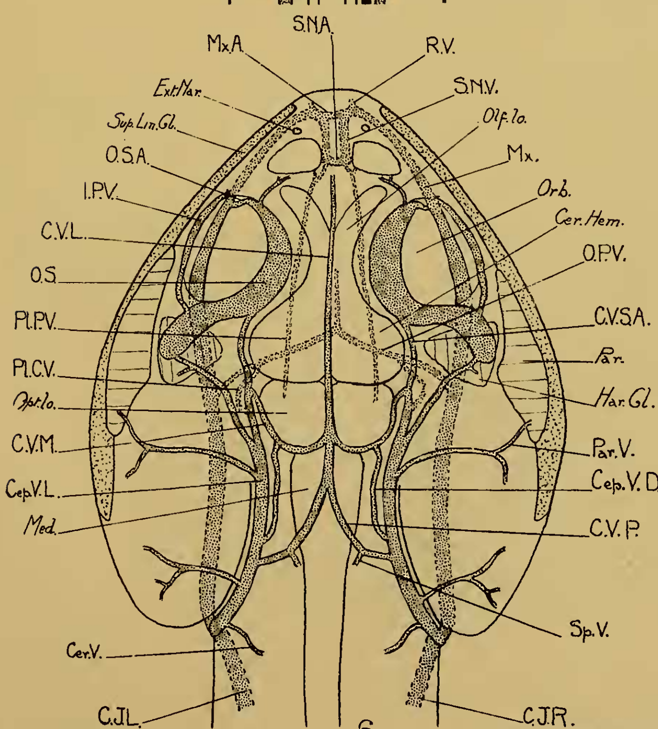




Chas. H O'Donoghue, del. Bale & Danielsson, Ltd imp.

CIRCULATORY SYSTEM OF THE GRASS SNAKE.

the snake most commonly dissected in the laboratories of this country, no description of its vascular system has appeared since the anatomical account of the blood-vessels in snakes written by Schlemm (**35**) in 1827, which was based largely on *Coluber* (i. e. *Tropidonotus*) *natrix* and *Trigonocephalus mutus.* This account by Schlemm, although excellent in many respects, is by no means complete, and, owing to the overlooking of the cerebral carotid artery, the remaining arteries of the head are misinterpreted. A great deal of work has been done, however, on different parts of the circulatory system of this animal by various authors. We are indebted to Rathke for a valuable account of its development (**30**) and also of the arteries of the head and neck (**31**); the last is the best general account of these vessels in snakes that has been written as yet. Hochstetter has dealt with the development of the posterior veins (**20**) and of the blood-vessels in general (**22**), Grosser and Brezina (**19**) with the development of the veins in the head and neck, and Bruner (**12**) with the veins and sinuses in the head of the adult.

In addition to these works bearing directly on *T. natrix*, Beddard (**1–6**) has added considerably to our knowledge of the blood-vessels of other snakes, and the intracranial circulation has been dealt with in the vertebrate series in general by De Vriese (**14**) and Hofmann (**24**) and in reptiles by Dendy (**13**).

The blood-vessels of the Grass-Snake were investigated by means of the dissection of a number of injected specimens. The injection fluid used for the main vessels was that recommended by Kingsley (**28**), *i. e.*,

Corn starch and 2 per cent. chloral hydrate (each) 400 vols.
95 per cent. alcohol 100 vols. and Colour and glycerine (equal parts) 100 vols.

For the finer vessels a gelatine mixture advised by Tandler (**36**) was used, *i. e.*,

5 gms. of gelatine in 100 c.c. of distilled water coloured with Berlin blue or carmine.
5–6 gms. of potassium iodide added slowly while warming gently.

These are two very good mixtures, as the first will keep almost indefinitely, and the second, with the addition of a few crystals of thymol, will keep in a stoppered bottle for months, and, in addition to being useable when almost cold, will withstand acids. By mixing a quantity of the gelatine mass with about one-third or less of its volume of the solid residue that settles to the bottom of the starch mixture, an extremely useful general injection mass is obtained. The latter mass, which flows very readily if only slightly warmed, and sets firmly and fairly quickly in 70 per cent. alcohol or in 4–5 per cent. formalin, was the one most frequently employed in making the preparations for this investigation.

For the sake of clearness in description, the account of the blood-vessels of the head is not included in the general description of the vascular system of the whole animal, but is dealt with separately later. A brief account of the development of the heart and of the arterial and venous systems has been introduced in order to throw some light on the condition that obtains in the adult.

Two or three features of general interest in connection with the elongation of the body and the loss of limbs in the Ophidia are clearly brought out in dealing with the vascular system of the Grass-Snake. The first is the marked asymmetry of the viscera and their blood-supply; not only are the organs of the right side anterior to those of the left, but they are also considerably larger. Thus the right ovary, supra-renal body, and the kidney are in front of and larger than the corresponding organs on the left, and, as is well known, in the case of the lungs the left one is entirely suppressed.

Secondly, the tendency to form longitudinal systems of vessels, common to all Ophidia, as Beddard (**1**) pointed out, is well marked. The various arteries supplying the intestine and the fat-bodies are in each instance indirectly connected into one long system. The ovarian artery forms a longitudinal trunk along the corresponding supra-renal body. Among the veins also we find that the hepatic portal vein runs from one end of the intestine to the other, and that each oviduct possesses a sinus running beside it for the greater part of its length. This oviducal sinus is very conspicuous in *T. natrix*, although it does not appear to have been described previously in other snakes. The liver, too, is greatly elongated, and the post-caval vein and the hepatic portal vein pass along its opposite faces from one end to the other.

Lastly, the blood-vessels of the adult, with the exception of a small pair of veins in the cloacal region, which may represent the pelvic veins of Lacertilia, give no indication of their derivation from those of a limb-bearing ancestor.

In conclusion I should like to express my sincere thanks to Professor J. P. Hill of this College for the kindly assistance and advice he has given me throughout the work.

II. The Heart. (Pl. LXX.)

(A) *Development.*

The development of the heart has been very fully dealt with by Rathke (**30**), and as this account differs but slightly from that of *Lacerta* given by Greil (**18**) and Hochstetter (**20**), it does not appear necessary to give more than a brief outline here.

The primitive heart is in the form of a simple tube stretching in an antero-posterior direction in the region of the gill-slits. Its posterior end is formed by the union of the two omphalo-mesenteric veins, and the anterior is continued as the short common stem (truncus arteriosus) of the first pair of branchial arches. It soon bends towards the right, and as the two ends remain in approximately the same position, while the tube itself grows longer, it is forced to take on a curved form. In this twisted condition three portions can be distinguished: first, a posterior part running from the union of the omphalo-mesenteric veins, close to which now open the paired ductus cuvieri, ventrally and towards the left; secondly, a median part situated ventrally and running obliquely from left to right; and thirdly, an anterior part running from the right to the median line, where it bends sharply dorsally before passing over into the truncus arteriosus, from which, by this time, two pairs of branchial arches are given off.

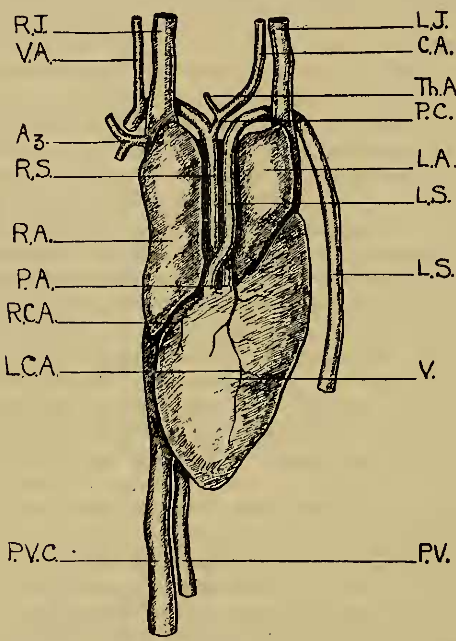
Grooves appear on the posterior part of the tube which indicate the divisions between sinus venosus and atrium and between atrium and ventricle. Into the sinus venosus now open the paired umbilical veins. The middle part, afterwards to become the ventricle, becomes dilated ventrally, and as the anterior part also dilates, the two parts are separated by a deep furrow. According to Hochstetter (20) and Langer (29) this anterior part is homologous with the bulbus cordis of the Batrachia.

The ventricle expands still further and moves caudally, so that the atrium, which has also become dilated, comes to lie close to the bulbus cordis. The further dilatation of the atrium takes place cranially and towards the left, causing it to take up a position on the left side of the bulbus. The constriction between the atrium and ventricle, corresponding to the auricular canal, becomes more marked as these two structures swell out. At this stage, too, the sinus venosus is sharply constricted off from the atrium and the truncus arteriosus gives off the six pairs of branchial arches. Rathke erroneously described only five branchial arches, but this will be referred to again later.

After this the ventricle gradually assumes its adult shape The base of the bulbus cordis, originally joining the ventricle on the left, moves into an almost mid-ventral position. Spirally twisted grooves appear between the branchial arches, now reduced to three in number, and extend downwards over the bulbus. The atrium now gives off another dilatation, but this time to the right, and consequently the truncus arteriosus and bulbus cordis lie in a deep groove between the outgrowths of the atrium. These two dilatations are the definitive auricles, and already the sinus venosus, which lies in the atrio-ventricular sulcus on the dorsal side of the heart, opens into the one on the right.

The groove between the bulbus and the ventricle gradually disappears, and ultimately the proximal part of the bulbus becomes incorporated with the latter, while its distal portion becomes assimilated to the truncus arteriosus. The spiral grooves finally extend over the whole of the so-formed truncus, and they indicate its internal division into three parts by the backward growth of two septa. One, the septum aortico-pulmonale, arises from the edge of the pulmonary artery, and as it grows it divides the truncus cavity into two tubes, an aortic and a pulmonary. The other, the septum aorticum, arises between the two aortic arches, and so subdivides the aortic cavity of the truncus into two, a right and a left. Of the three tubes formed in this way, one lies to the left, ventrally, and leads to the pulmonary arch; another lies to the right, ventrally, and leads to the left aortic arch; and the third lies dorsally and leads to the right aortic arch.

Text-fig. 86.

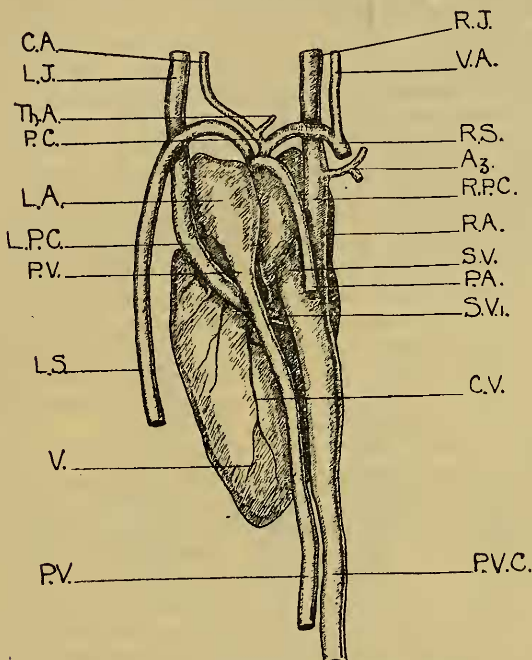


Ventral view of the heart and adjoining vessels.

Az. Azygos vein. C.A. Left common carotid artery. L.A. Left auricle. L.C.A. Left coronary artery. L.J. Left common jugular vein. L.S. Left systemic arch. P.A. Pulmonary artery. P.C. Primary carotid. P.V. Pulmonary vein. P.V.C. Post-caval vein. R.A. Right auricle. R.C.A. Right coronary artery. R.J. Right common jugular vein. R.S. Right systemic arch. Th.A. Thyroid artery. V. Ventricle. V.A. Vertebral artery.

Lastly, the sinus venosus also assumes its definitive form. After the disappearance of the umbilical and omphalo-mesenteric veins, it has opening into it, on the right, the right ductus Cuvieri and the post-caval, while on the left it has the left ductus Cuvieri. Thus we have practically the adult condition of the heart, which, however, in the course of the further development moves caudally, and ultimately comes to lie a long way from its primitive position.

Text-fig. 87.



Dorsal view of the heart and adjoining vessels.

C.V. Coronary vein. L.P.C. Left pre-caval vein (left common jugular). R.P.C. Right pre-caval vein (right common jugular). S.V. Major part of sinus venosus. S.V.1. Minor part of sinus venosus. Other letters as in text-fig. 86.

(B) *Adult Form.*

Tropidonotus in common with all the reptiles, except the Crocodilia, possesses a three-chambered heart. This is situated a considerable distance behind the head and slightly towards the right. It is enclosed in a pericardium in which it lies freely, not being attached to it by a gubernaculum cordis as is the case in the heart of the Lacertilia and Crocodilia. Beddard (**2**) has pointed out that although a gubernaculum cordis is generally absent in snakes, it is not completely so, as a homologous structure occurs in some species *. The pericardium on the right side lies

* E. g. *Coronella getula*, *Cœlopeltis monspessulana*, and *Ophiophagus bungarus*, Beddard (*loc. cit.*).

against the body-wall, while on the left side it is separated from it by the intervention of the œsophagus. In conjunction with the elongated form of the body, we find that the heart also is long and narrow.

The *Sinus Venosus* is situated on the dorsal surface of the heart, and appears as a saccular structure divided into two parts and formed by the swollen extremities of the common jugular veins and the post-caval veins (text-fig. 87). It is hardly distinguishable externally from the right auricle, although internally the two cavities are separated by the bicuspid sinu-auricular valve. The right common jugular vein from the anterior end of the body and the post-caval from the posterior end join together to form the major part of the sinus venosus, which lies on the right of the dorsal surface of the heart. The left common jugular vein runs down along the outer edge of the left auricle and then across in the groove between the left auricle and ventricle (text-fig. 87). Its mouth opens into the smaller part of the sinus venosus *, which is partially separated from the major part by a valvular septum. The efficacy of this septum is seen when injecting, for while the right common jugular and post-caval veins may be easily injected from the major part of the sinus, it is almost impossible to inject the left common jugular from it.

The thin-walled *Auricles* (text-fig. 86) are unequal in size, the right, of an elongated oval form, being much larger than the left, which is shorter and more rectangular. Into the right auricle opens the sinus venosus and into the left the single pulmonary vein (text-fig. 87). The opening of the pulmonary vein is not guarded by a valve as Fritsch (**16**) pointed out, but it seems highly probable, as Sabatier (**33**) suggested, that during systole a fold of the auricle in this region functions as a valve and so prevents regurgitation. The auricles are completely separated by an imperforate inter-auricular septum which is continued caudally so as to divide the auriculo-ventricular aperture into two. The internal surfaces of the auricles possess a network of raised muscular ridges, the musculi pectinati.

The *Ventricle* is somewhat oval in shape, but very asymmetrical. The posterior end forms a bluntly conical apex, and the base, although more or less transverse on the right side, is produced anteriorly on the left side into a conical process, so that the left side of the ventricle is nearly as long again as the right. It is extremely thick-walled, and its cavity contains a large number of muscular trabeculæ, some of which interlace in such a way as to form an oblique, incomplete ventricular septum. This partial septum keeps the aerated blood brought in by the left auricle more or less completely separated from the non-aerated blood from the right auricle. Two valves, a right and a left, similar in arrangement to those in Lacertilia, guard the auriculo-ventricular apertures.

* They do not open separately into the auricle as stated in Rolleston (**32**).

The *Bulbus cordis*, as has been pointed out above, is not to be found as a separate structure in the adult, and so the three aortic arches arise directly from the ventricle. The base of each of these is guarded by two semilunar valves, which Langer (29) has shown to be homologous with the distal row of valves in the amphibian heart.

III. The Arterial System. (Pl. LXX.)

(A) *Development.*

The development of the aortic arches in *Tropidonotus* is very similar to that of other Reptilia*. It was first described by Rathke (30), whose general account has been confirmed since by Van Bemmelen (7 & 8) except in one particular. Rathke

Text-fig. 88.

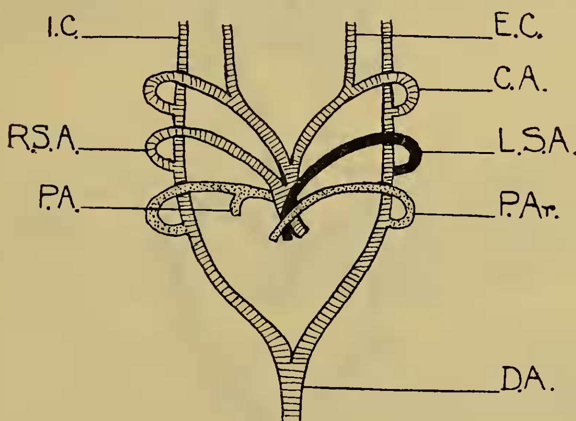


Diagram of embryonic arterial arches. It represents the condition after the disappearance of arches 1, 2, and 5, and shows also the division of the truncus arteriosus into three arterial roots.

C.A. Common carotid. D.A. Dorsal aorta. E.C. External carotid. I.C. Internal carotid. L.S.A. Left systemic arch. P.A. Pulmonary artery. P.Ar. Pulmonary arch. R.S.A. Right systemic arch.

Adapted from Hochstetter (22).

describes the development of only five visceral arches on each side, which he numbered from the anterior end 1–5. Van Bemmelen, however, showed that there was another arch, which has however, a somewhat transient existence, between arches 4 and 5 of Rathke, so that the latter's fifth arch is in reality the sixth of the series, and thus the snake is brought into line with other Amniota.

* For a general account of this see Hochstetter (22).

These arches soon become reduced to three on each side, viz. 3, 4, and 6, by the disappearance of arches 1, 2, and 5. Of the remaining arches, 3 is the carotid, 4 the systemic, and 6 the pulmonary. By the separation of the truncus arteriosus into three tubes the two carotids and the right systemic have a common opening into the ventricle; the left systemic opens separately, and the two pulmonaries open by a common vessel (text-fig. 88). The most remarkable change in the development is the enormous lengthening of the carotids, brought about partly by the elongation of the neck but largely by the caudal shifting of the heart. Thus it happens that in the adult condition the 3rd arch is far removed from the 4th and 6th arches.

Text-fig. 89.

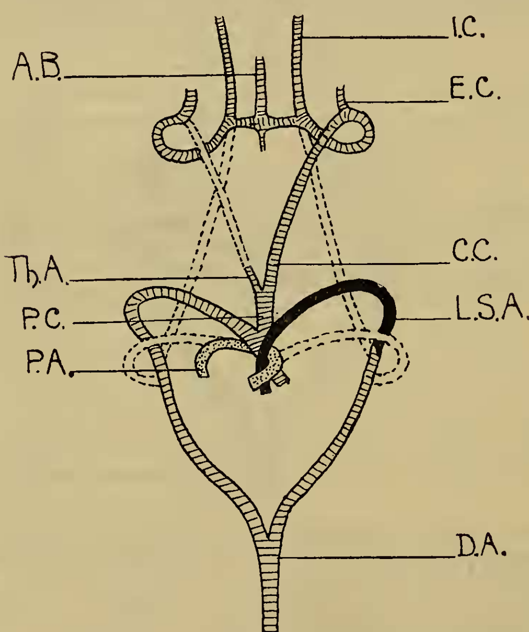


Diagram to show changes in embryonic arterial arches. It shows the change from the condition in text-fig. 88 to the definitive state. The filled-in portions represent the vessels left in the adult, and those indicated by dotted lines the vessels that disappear in the course of development.

A.B. Basilar artery. C.C. Left common carotid. P.C. Primary carotid. Th.A. Thyroid. Other letters as in text-fig. 88.

Adapted from Hochstetter (**22**).

The *Carotid Arch* goes through considerable changes in the course of its development. The two common carotids arise from the systemic by one root, the primary carotid (carotis primaria of Rathke), which remains short as in most snakes *. After the common carotids have split into internal and external carotids, each internal vessel gives off a branch which enters the neural canal with the first spinal nerve and joins the basilar artery on the ventral side of the nerve-cord. These branches quickly widen out and, forming as they do an anastomosis between the two internal carotids, make it possible for the right common carotid to degenerate. This it does completely † from the point where it divides into internal and external branches down to close to its union with the left common carotid, but the last part of it remains and is to be found in the adult as a small artery supplying the Thyroid gland (text-fig. 89).

The *Systemic Arch* undergoes very little change during development.

The *Pulmonary Arch* degenerates almost completely on the left side. In conjunction with the suppression of the left lung in *Tropidonotus*, we find that the pulmonary branch of the 6th arch is only developed on the right side. In the adult only one pulmonary artery is to be found.

(B) *Adult Form.*

(*a*) Anterior Vessels.

The *Left Aorta* bends dorsally around the œsophagus and trachea and then posteriorly to unite with the right aorta in the mid-dorsal line. During this course it gives off two very small branches to the œsophagus, but none whatever to the parietes.

The *Right Aorta* takes a corresponding course on the other side, during which it gives off the following branches:—

I. The *Left* and *Right Coronary Arteries* arise behind the two semi-lunar valves which guard the base of the aorta. The right coronary artery runs in the groove between the auricle and ventricle, and is the chief supply of the dorsal surface of the heart. The left passes around the base of the pulmonary artery and spreads out over the ventral side of the heart.

* In some snakes it is absent altogether, so that the common carotids come off separately from the systemic arch, e. g. *Boa*.

† It is interesting to note, however, that in some variations of *T. natrix* this does not occur, and so the two common carotids persist in the adult. The first specimen of *T. natrix* that I examined was in this condition, although in all other respects it appeared a perfectly normal adult male. The two common carotids, left and right, sprang from a common stem, the primary carotid, and were about equal in calibre. On the left side the carotid pursued a normal course. The abnormal right carotid passed ventral to the œsophagus, just behind the thyroid gland, to which it sent a small branch, over to the right side of the neck. From here up to the posterior end of the skull it followed a similar course to its fellow on the left. Unfortunately the vessels of this specimen were not injected, so that the relation of the persistent right carotid to the basilar artery could not be ascertained. However, this apparent anomaly in the arterial system is quite readily understood in the light of the developmental history of these vessels. Only one other example of this peculiar abnormality seems to have been described before, and that by Van Bemmelen (9), but in this case the right carotid was only a fine tube.

II. The *Primary Carotid* (Carotis primaria, Rathke) is a short trunk which quickly divides into two unequal branches:—

i. The *Thyroid Artery* is the smaller of the two, and, in addition to supplying the thyroid gland, it sends a twig to the right thymus glands. This is the sole remnant of the right common carotid.

ii. The *Left Common Carotid* (Arteria carotis communis, Rathke, Arteria cephalica, Schlemm) runs along the left side of the œsophagus and trachea, to which it sends three or four slender branches, until it reaches the posterior region of the head. Here it divides into internal and external branches, and supplies the whole of both sides of the head. (The distribution of this vessel in the head will be dealt with later.)

III. The *Vertebral Artery* (Arteria vertebralis, Rathke, Arteria collaris, Schlemm) arises from the anterior dorsal part of the right carotid arch and runs forward, a little to the right of the vertebral column about half-way to the head. It gives from three to seven branches to the parietes and one or more to the œsophagus before disappearing into the vertebral musculature in the mid-dorsal line.

IV. Five *Parietal Arteries* are then given off. The first three are very slender and close together, while the remaining two are of the same size as the regular parietal arteries.

V. One or two small *Œsophageal Arteries* run to the œsophagus. After this the two systemic arches unite to form a single vessel, the dorsal aorta.

The *Left Ductus Botalli* is not completely closed up in the course of development, and its proximal portion is to be found in the adult animal as a cul-de-sac running cranially from a point low down on the root of the right carotid arch *. This remnant varies somewhat in size in different individuals, and although it is always more or less short, is of nearly the same calibre as the right carotid. It is completely hidden by the left auricle, but is readily seen if that body be carefully removed. From its somewhat bluntly conical end comes off a thin strand of tissue which runs forward into the left systemic arch at the point where it bends over to run backwards. This represents the closed part of the left pulmonary arch, and is therefore the left ligamentum Botalli, such as has been described by Brenner (**11**) and Hochstetter (**21**). I find myself in agreement with the former author also when he states that he was unable to find a right ligamentum Botalli in *Tropidonotus natrix*.

According to Brandt (**10**), quoted also by Hoffman (**23**), there

* Such a saccular appendage appears to be present generally in those snakes with one lung suppressed, and has been recorded by Hochstetter (**21**) in *Tropidonotus natrix*, *T. tesselatus*, *Coluber æsculapii*, *Coronella lævis*, *Vipera berus*, and *Cerastes vipera*.

is present in the Grass-Snake a solid strand of tissue joining the primary carotid to the transverse part of the left aortic arch and called by him the ligamentum caroticum. This, he states, in exceptional cases may remain open and may then be described as a ductus caroticum, and is a vestigeal structure somewhat similar to the ductus Botalli. In the hearts I have examined no trace of this vessel or cord could be found, and, indeed, no such connection exists in the course of embryonic development, as a glance at text-figs. 88 and 89 will show. A connection between the carotid and left aortic arches is present in the embryo, but in the adult it would run from the dorsal part of the left systemic arch along the whole length of the neck up to the point of origin of the internal carotid (text-fig. 89). This, however, does not fit in with Brandt's description of the ligamentum caroticum.

(*b*) **Posterior Vessels.**

The *Right Pulmonary Artery* (Arteria pulmonalis, Schlemm) arises separately from the ventricle and leaves the heart the most dorsal of the three arterial roots. It runs backwards alongside the œsophagus almost parallel with the right systemic over which, however, it passes ventrally, and then runs dorsal of the post-caval vein to the anterior end of the lung. As it passes along the right border of that organ it gradually gets smaller and smaller until it disappears as a distinct vessel at the level of the posterior end of the liver, although the lung is continued on for some distance.

In correlation with the suppression of the left lung no left pulmonary artery is found at any time.

The *Right and Left Aortic Arches* unite posterior to the heart to form the dorsal aorta.

The *Dorsal Aorta* runs in the body-cavity just ventral to the vertebral column, back to the level of the cloaca. Just posterior to this it leaves the body-cavity and enters the hæmal canal, and in this is continued along the tail as the *Caudal Artery*. During its course through the cœlom it gives off a number of branches.

The *Parietal Arteries* form a numerous and more or less regular series of branches going to the body-wall, of which there are about twelve up to the point of origin of the superior mesenteric artery. These arteries enter the body-wall in the mid-dorsal line, a characteristic of most colubrine snakes, and do not split into two before so doing, as in the pythonine snakes (*cf.* Beddard, 4 and 1).

The *Œsophageal* and *Hepatic Arteries.*—In front of the liver the dorsal aorta gives off two or three slender branches to the œsophagus. After these come a series of common trunks, about fifteen in number, which divide into two branches, one going to the liver and one to the œsophagus or posteriorly to the stomach. The last of this series is considerably larger than the others and has more branches, some of which go to the anterior end of the stomach.

The following vessels then come off from the dorsal aorta in order:—

1. The *Lieno-gastric Artery* is the first of these. Its gastric branch is the main artery supplying the stomach, and it also sends a branch to the spleen, and yet a third, the cystic artery, to the gall-bladder. No branch of it goes to the pancreas, nor does the superior mesenteric artery send twigs to the spleen and gall-bladder as Beddard (1) has described in *Tropidonotus fasciatus*.

2. The *Superior Mesenteric Artery* is the largest vessel arising from the dorsal aorta. Soon after its origin at about the level of the pancreas it divides into two branches; a smaller one, the duodenal, running anteriorly supplies the part of the intestine immediately after the pylorus and also the pancreas; a much larger one running posteriorly supplies the many coils of the intestine as far back as the posterior end of the right ovary. Small branches from it also supply the anterior part of the fat-body. I have been unable to find any branch of this artery running to the right ovary such as Beddard (1) recorded in *Tropidonotus fasciatus*.

3. The *Right Ovarian Artery*, a moderate-sized vessel, runs to the right supra-renal body and, dividing into anterior and posterior branches, forms a longitudinal vessel along it. From this longitudinal trunk are given off:—

(*a*) Six small ovarian arteries of equal size.
(*b*) Three somewhat larger oviducal arteries. One of these arises from the anterior end of the longitudinal vessel and supplies the fimbriated opening of the oviduct, and the other two arise from the posterior end.
(*c*) Three fat-body arteries—an anterior, a small median, and a posterior.
(*d*) A number of fine twigs to the supra-renal body.

The posterior of the three fat-body arteries in some cases has an independent origin from the aorta.

4. The *First Inferior Mesenteric Artery* supplies the coils of the intestine just posterior to the right ovary. Its point of origin varies, however, in different individuals and in the two sexes, as will be pointed out below.

5. The *Anterior Right Renal Artery* conveys blood to the anterior half of the right kidney, and also gives off a branch to the right oviduct.

6. The *Left Ovarian Artery* is distributed in a very similar way to the right, and from the longitudinal trunk it forms along the supra-renal body come off:—

(*a*) Five equisized ovarian arteries.
(*b*) Three oviducal arteries. The anterior again supplies the oviducal funnel.
(*c*) Two fat-body arteries.
(*d*) A number of fine twigs to the supra-renal body.

As on the right side the posterior of the fat-body arteries may arise separately from the aorta.

7. The *Anterior Left Renal Artery* divides soon after its origin into two branches, one going to the fat-body and the other to the kidney. This latter branch supplies the anterior half of the kidney and sends a twig to the oviduct.

8. The *Second Inferior Mesenteric Artery* arises about the level of the anterior end of the left kidney, and supplies the intestine in the region of the median part of the right kidney.

9. The *Median Right Renal Artery*, in addition to taking blood to the posterior median part of the kidney, sends a branch to the right oviduct.

10. The *Posterior Right Renal Artery* feeds the posterior end of the kidney and gives off two branches to the oviduct.

11. The *Third Inferior Mesenteric Artery*, arising near the level of the posterior end of the right kidney, supplies the intestine in the region of the posterior part of the left kidney.

12. The *Median Left Renal Artery* is distributed very similarly to the corresponding vessel on the right.

13. The *Fourth Inferior Mesenteric Artery*, arising at the level of the posterior end of the left kidney, supplies the last part of the intestine.

14. The *Posterior Left Renal Artery* resembles its fellow on the right, save that it does not send a branch to the oviduct.

15. The *Posterior Oviducal Arteries* are a pair of arteries running to the posterior ends of the oviducts. In addition to this there may be one or two small twigs going to the rectum.

16. The *Rectal Artery* is a small vessel supplying the last part of the rectum.

An *Epigastric Artery* is present, and it appears to be similar to that described by Beddard (1) in *Ophiophagus bungaris*, that is, it runs along the body-wall in the mid-ventral line in close connection with the epigastric vein, and is fed by branches from the carotid anteriorly and the fat-body posteriorly. Its precise relations are somewhat difficult to make out, for it is a vessel too small for individual injection, and in order to get a satisfactory injection of the arterial system it is necessary to open the snake from end to end, dissect away the skin, and free the gut to some extent. This, however, necessitates cutting either the epigastric artery itself or some of its small tributaries.

The arrangement of the vessels in the male snake is very similar to that just described for the female. All the arteries anterior to and just posterior to the heart are precisely the same, and it is not until the region of the urino-genital organs is reached that we find any difference.

Each testis receives one spermatic artery as is general in snakes, which first runs to the supra-renal body, whence it sends branches to the testis and also to the vas deferens. These two spermatic arteries are each followed by another vessel that runs to the posterior part of the supra-renal body and also supplies the vas deferens for a considerable distance, that on the right side also sends a branch to the fat-body.

The kidneys each possess an anterior and a median renal artery as before, but instead of one posterior trunk there are at least two, but most often three *. These vessels also send small twigs to their respective vasa deferentia, and the left anterior renal supplies the fat-body with a large artery.

The supply to the alimentary canal is also slightly different. The first of the inferior mesenteric arteries arises posterior to the anterior left renal artery, whereas in the female it is anterior to the anterior right renal †. This is followed by a series of about four smaller inferior mesenteric arteries. The various mesenteric arteries are connected by their small branches and so form more or less of a longitudinal system along the gut.

The origin of the arteries supplying the fat-bodies in both sexes is fairly similar and is somewhat interesting. The anterior part is supplied by branches from the superior mesenteric artery, the next portion by vessels from the right genital artery, and the posterior end is fed by branches from the left genital and left renal supply. In addition to which the posterior branch from the genital artery on each side may in some cases arise independently from the dorsal aorta. All these branches are joined one to the other by small twigs into a longitudinal system running the whole length of the fat-body, but there does not appear to be one unbroken artery, an arteria epiploica, traversing the whole length of the fat-body.

IV. The Venous System. (Pl. LXX.)

(A) *Development.*

The general course of the development of the venous system in *Tropidonotus* is similar to that of other reptiles (*vide* Hochstetter, 22), but it has some points peculiar to itself (*vide* Rathke, 30, and Hochstetter, 20).

The first veins to appear are the two omphalo-mesenterics, of which the right is somewhat stouter than the left (the reverse is the case in *Lacerta*), and they open into the sinus venosus. Soon after their appearance the anterior and posterior cardinal veins arise on each side, and their common stem unites with the umbilical vein on each side to form the ductus Cuvieri, which becomes associated with the omphalo-mesenteric veins at the

* The number of renal arteries varies in different species, being only one in *Python spilotes* and eight in *Coronella catenifer*, Beddard (1).

† This differs from the account of *T. fasciatus* in Beddard (1), where "it springs from the aorta in both sexes close to the second (*i. e.* left) gonad artery, in front of it in the male, behind it in the female." Some variation is to be found, however, in the position of this artery in different individuals, for in the females of *T. natrix* that I have examined, although it has generally been in front of the right anterior renal and left ovarian arteries, it may be behind these vessels. In the male it is usually behind the left anterior renal artery, but it may be in front of it. It has not occurred anterior to the right anterior renal artery in any male snake that I have examined. Again, we find considerable variation in the number of these gut-arteries in various snakes. *Lachesis gramineus* has only one, while in the genus *Coluber* there may be ten or eleven (Beddard, *loc. cit.*).

point where they open into the sinus venosus. An anastomosis between the two omphalo-mesenteric veins forms on the dorsal side of the gut just posterior to the pancreas rudiment, and the portion of the left vein between this point and the sinus venosus disappears. A similar anastomosis between the two veins now forms on the ventral side of the gut, and thus a complete ring is formed. In a short time, however, the right half of this ring disappears, leaving a single vein which runs in a spiral manner round the gut. While these latter changes are taking place, the middle part of the right omphalo-mesenteric vein between the sinus venosus and the dorsal anastomosis spreads out and forms a venous network in the liver. The portion of the right omphalo-mesenteric vein in front of the hepatic network persists as the hepatic vein, and the part behind it always remains as the anterior end of the hepatic portal vein (text-fig. 90).

Text-fig. 90.

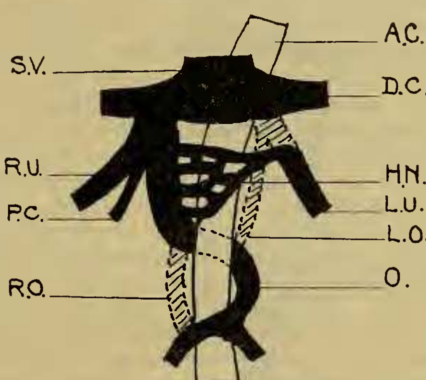


Diagram of posterior veins in the embryo. It shows the change from an early to a late embryonic condition. The shaded vessels being the first to disappear.

A.C. Alimentary canal. D.C. Ductus Cuvieri. H.N. Hepatic network. L.O. Left omphalo-mesenteric (soon disappears). L.U. Left umbilical. O. Omphalo-mesenteric. P.C. Post-caval. R.O. Right omphalo-mesenteric (disappears later than L.O.). R.U. Right umbilical. S.V. Sinus venosus.

Adapted from Hochstetter (**20**).

The posterior cardinal vein originates at the caudal end of the mesonephros, and runs forward along the dorso-lateral edge of that body. After leaving the kidney, however, it breaks into several branches, which soon reunite and then it runs into the ductus Cuvieri. When the caudal vein develops it divides into two branches at its anterior end, each of which runs to the extremity of the corresponding cardinal vein (not along the mesial wall of the kidney as in *Lacerta*). The post-caval vein springs from the union of the right umbilical and omphalo-mesenteric veins and runs backwards in the mesentery to the kidneys. Between them it breaks up into two branches, which run posteriorly along their mesial borders. These branches meet the kidneys at a point some distance from their front end, and there each receives a branch from the anterior part of the kidneys. Subsequently the parts of the posterior cardinal veins in front of each mesonephros disappear, and so all the blood from the caudal veins has to pass through those organs.

Still later the adult kidney arises caudally to the mesonephros, and then the end part of each posterior cardinal vein comes to lie on its ventral and external border, while a continuation of one of the posterior mesonephric branches of the post-caval vein extends along the inner border of the permanent kidney.

The left umbilical vein loses its opening into the ductus Cuvieri, and all its blood is taken to the liver network. The right umbilical vein, on the other hand, retains its original opening into the ductus for some time (text-fig. 90). In the subsequent changes the post-caval vein increases in size, and the part of the omphalo-mesenteric vein joining it breaks up into a venous network with the caudal extension of the liver. As the two umbilical veins are joined by an anastomosis at the navel, it is possible for the right to disappear, which it does, leaving the left, which, however, disappears soon after birth *. Ultimately the omphalo-mesenteric vein, lying on the dorsal side of the liver, can only communicate with the sinus venosus *viâ* the hepatic network and the post-caval vein, which is on the ventral side of the liver.

The anterior cardinal veins originate in a similar way to those of Selachians and Amphibians, but the parts of these veins in the head are completely replaced in an interesting way (*vide* Grosser and Brezina, **19**). The original cardinal vein runs backwards from the infraorbital and the anterior cerebral veins ventrally to the cranial nerves into the ductus Cuvieri. Three venous rings are now formed in succession; the first around the root of the facial nerve and the auditory vesicle, the second around the root of the glossopharyngeal nerve, and the third around the vagus root. Their median portions afterwards disappear, and the external ones unite to form one lateral trunk. In the meantime two new vessels come to open into the anterior cardinal: one, the median cerebral vein, coming from the cerebellum, opens just posterior to the trigeminal nerve; and the other, the posterior cerebral vein, coming from the medulla, opens posterior to the vagus, leaving the skull by the foramen magnum.

Still later the lateral trunk opens anteriorly into the infraorbital vein by means of an extension by the side of the second and third branches of the trigeminal nerve, and posteriorly past the hypoglossus into the anterior cardinal opposite to the posterior cerebral vein. In this way is formed a new, complete

* Generally the umbilical vein disappears in the adult snake, but remains of it persist in some species, e. g. *Boa constrictor*, *B. diviniloqua*, *Python regius*, *Eunectes murinus*, *Corallus cookii* (Beddard, **4** & **5**).

lateral trunk, the lateral cephalic vein (V. capitis lateralis, Grosser and Brezina). At the same time the three cerebral veins become connected by a median longitudinal vessel (text-fig. 91). Further, two new anastomoses arise from the median cerebral vein, one goes to the anterior cerebral vein and the other, the secondary median cerebral vein, leaving the skull with the trigeminus, goes to the lateral cephalic vein. This becomes the main vein leading from the anterior part of the brain.

Text-fig. 91.

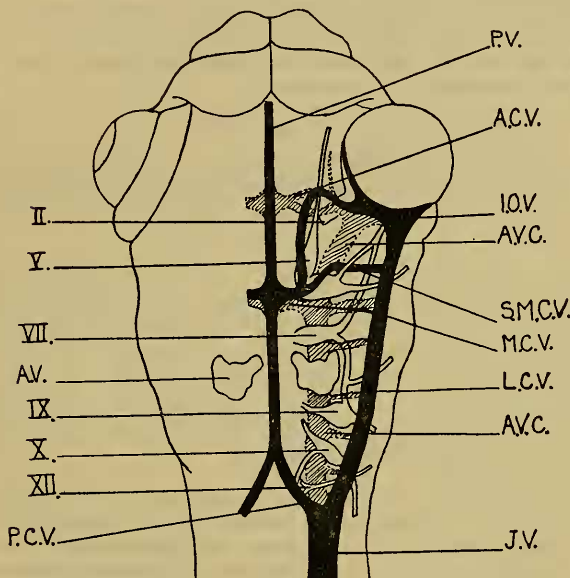


Diagram of veins in the region of the head in the embryo. It shows the original veins indicated by the shaded portions and the definitive vessels indicated in black.

A.C.V. Anterior cerebral. A.V. Auditory vesicle. A.V.C. Anterior cardinal. I.O.V. Infra-orbital. J.V. Right common jugular. L.C.V. Lateral cephalic. M.C.V. Median cerebral. P.C.V. Posterior cerebral. P.V. Prosencephalic. S.M.C.V. Secondary median cerebral. II, V, VII, IX, X, XII, Primordia of cranial nerves.

Adapted from Grosser and Brezina (**19**).

The adult condition is reached by the regression of the dorsal part of the anterior cerebral vein, the complete disappearance of the portion of the anterior cardinal vein in the head, leaving its cervical part, however, as the common jugular vein, and the formation of a vein bringing back blood from the upper and lower jaws.

(B) *Adult Form.*

(*a*) Anterior Vessels.

The whole of the blood from the head is brought back to the heart by the two common jugular veins. The distribution of the veins in the head and their union to form the common jugulars will be dealt with later.

The *Left Common Jugular Vein* * (V. jugularis sinister, Schlemm) runs from the anterior end of the neck parallel with and close to the left common carotid artery to the heart. It passes ventral to the left systemic arch to the dorsal side of the left auricle, and it runs along the dorso-lateral edge of this structure to the auriculo-ventricular sulcus. Here it bends sharply to the right and runs into a part of the sinus venosus somewhat sharply marked off from the remainder. It receives :—

i. In its anterior part a few small tributaries from the anterior end of the œsophagus.
ii. The *Coronary Veins* (text-fig. 87), a series of small vessels which join it in its course along the auriculo-ventricular sulcus.

The *Right Common Jugular Vein* * (V. jugularis dextra, Schlemm) is similar in disposition to the left, but at the level of the anterior end of the right auricle it receives a large tributary, the azygos vein. After this it runs straight on and unites with the post-caval vein to form the major part of the sinus venosus.

I. The *Azygos Vein* (V. azygos, Schlemm) is a short trunk leading into the right common jugular vein from the union of the anterior and posterior azygos veins.

A. The *Anterior Azygos Vein* (V. azygos anterior, Schlemm) lies in front of the heart between the œsophagus and the backbone, and extends from the beginning of the neck back to the heart. It collects blood from the dorsal body-wall along this region by means of a fairly regular series of intercostal veins, all of which come off to the right of the vertebral column. Just before it unites with the posterior azygos vein it receives a branch from the œsophagus.

(*a*) The *Œsophageal Vein* is formed at the level of the front end of the thyroid gland by the union of two branches. One of these branches comes from the anterior dorsal part of the œsophagus, and the other from the posterior dorsal part. Their common stem runs almost straight to the right, ventral to the vertebral artery and dorsal to the right common jugular vein, and opens into the anterior azygos vein.

* It is to be noted that the proximal parts of these two veins are homologous with the precaval veins of Lacertilia. As, however, there is no representative of the subclavian veins to mark the beginning of the precaval portion, it is convenient to apply the one name to the whole vessel.

B. The *Posterior Azygos Vein* (V. Azygos posterior, Schlemm) is a much shorter vessel than the anterior, and also than the homologous vein in *Lacerta*. It originates at about the level of the middle of the ventricle, and runs forward to meet the anterior azygos just anterior to the right auricle. In its course it receives three or four intercostal veins, all of which come from the body-wall to the right of the vertebral column.

(*b*) **Posterior Vessels.**

The *Right Pulmonary Vein* (V. pulmonalis, Schlemm) first becomes noticeable as a definite vessel on the left side of the lung at the level of the posterior end of the liver. It runs forward along that organ to its anterior end, receiving numerous branches and, leaving the lung, it runs parallel to the post-caval vein and ventral to the right systemic arch to open into the right auricle.

A left pulmonary vein never exists at any time.

The *Caudal Vein* (V. caudalis, Schlemm) arises far back in the tail and runs forward in the hæmal canal, together with the caudal artery. It leaves this canal and divides into two branches, the renal portal veins, a short distance before reaching the cloaca.

The *Renal Portal Vein* (V. venalis advehens, Schlemm) on each side runs forward from the bifurcation of the caudal vein over the cloaca and along the outer side of each kidney. It receives soon after its origin a lateral tributary, which from its position and distribution appears to correspond to a pelvic vein *. If this be the case, it is interesting as being the only indication in the circulatory system of the derivation of the snake from a limb-bearing ancestry. Each renal portal vein receives several small tributaries from the dorsal body-wall, the cloaca, and the lateral part of the tail. It then passes over the cloaca and lies between the oviduct which is on its outer side and the ureter which is on its inner side. Shortly after passing the cloaca each vein gives off a well-marked branch, the right being anterior to the left, which passes dorsally around the ureter and then runs ventrally to unite with its fellow on the dorsal wall of the gut. The vein so formed, the "Veine mésentérique postérieure" of Jourdain (27), runs forward along the gut and is continued as the hepatic portal vein. In its course from the cloaca to the kidney each renal portal vein receives a number of small tributaries from both ureter and oviduct, one of which, the *Posterior Oviducal Vein*, is well marked, and also one or more from the dorsal parietes. On reaching the kidney it runs along its lateral border closely accompanying the ureter, and, gradually getting smaller, disappears at the anterior end of that organ. It is not continued anterior to the kidney as in some snakes, *e. g.* the Boidæ and also in *Zamenis gemonensis* (Beddard, 4 & 2), a feature recalling the condition in the Lacertilia. During its course along the posterior part of the kidney this vein receives a well-marked tributary from the oviduct.

* A similar pair of veins is to be found in *Eunectes murinus* (Beddard, 2).

The *Right Efferent Renal Vein* (V. venalis revehens, Schlemm) originates along the inner margin of the kidney at its posterior end, runs to the anterior end, and after a short independent course in front of the kidney unites with its fellow of the opposite side to give rise to the post-caval vein.

The *Left Efferent Renal Vein* also has its origin along the inner margin of the kidney. But, unlike the right, it receives branches from the supra-renal body, the ovary, and the left oviduct in its course from the kidney to the point where it unites with its fellow. Thus:—

i. The *Left Ovarian Veins* are numerous small tributaries flowing into the left efferent renal veins.

ii. The *Left Supra-Renal Veins* are a large number of small branches running from the supra-renal body into the efferent renal vein, to which it is closely attached. They return the blood brought to that body by the supra-renal portal veins.

iii. The *Left Oviducal Vein* is a large vein leaving the oviduct at the level of the fimbriated funnel and flowing into the efferent renal vein just in front of the supra-renal body. It returns blood from the oviducal sinus.

A. The *Left Oviducal Sinus* is a wide thin-walled vessel which runs from the extreme anterior end of the oviducal funnel backwards to about the level of the middle of the corresponding kidney. It is very conspicuous in injected specimens and was present in all the female examples of *T. natrix* that I have examined, although it does not appear to have been recorded in any other Ophidian.

The *Post-Caval Vein* (V. cava posterior, Schlemm) is formed, as has been stated above, by the union of the two efferent renal veins. It passes forward, dorsal to the gut, freely in the mesentery to the posterior extremity of the liver, and then along in a groove in the ventral surface of that organ to its anterior end. After leaving the liver it runs almost straight forward, ventral to the right systemic arch and unites with the right pre-caval to form the larger division of the sinus venosus. Soon after its origin it receives veins from the right ovary, the supra-renal body, and the oviduct. Thus:—

i. The *Right Ovarian Veins* are similar to those of the opposite side.

ii. The *Right Supra-Renal Veins* also resemble those on the left and return the blood gathered by the supra-renal portal veins.

iii. The *Right Oviducal Vein* is like its fellow on the left and comes from an oviducal sinus.

A. The *Right Oviducal Sinus* extends along the oviduct from the anterior end of the funnel to about the level of the middle of the right kidney.

The *Supra-renal Portal System.*—Each supra-renal body has a portal supply, an arrangement of vessels which is universally present in snakes according to Beddard (1), who, however, attributes the discovery of this system to Gratiolet in 1853 (17), whereas it had been described seven years previously by Ecker (15). The supply consists of two, but in more rare cases of three, intercostal veins which arise from the corresponding side of the dorsal body-wall and also of a vessel from the oviducal sinus in the female, all of these pour their blood into the supra-renal network. The last of these vessels is rather small and runs at the level of the middle of the ovary on each side.

The *Hepatic Portal Vein* (Vena portæ, Schlemm) arises by two roots, from the renal portal veins, which unite to form a single vessel on the dorsal wall of the rectum in a way that has already been described *. It passes forward through the gut mesentery, receiving on its way numerous branches from the many coils of the small intestine and also from the fat-body. Towards its anterior end a tributary joins it bringing blood from the front part of the intestine, the pancreas, and the spleen. This is shortly followed by another vein coming from the gall-bladder. In the same region it is joined by the anterior abdominal vein which runs down from the fat-body. From this point instead of being on the ventral side of the post-caval vein it passes dorsally to the left of this vessel and enters a furrow on the dorsal side of the liver. Between the entrance of the vein from the pancreas and the spleen and the posterior end of the liver, *i. e.* just anterior to the superior mesenteric artery, the hepatic portal vein receives three large intercostal veins from the parietes of the right side. The vessel runs in the groove of the liver right to its anterior end, gradually diminishing in calibre, and it receives in this part of its course a more or less regular series of intercostal veins arising to the left of the vertebral column and a greater number of small veins from the stomach and œsophagus. A very similar condition obtains in *T. fasciatus* (Beddard, 1).

I. The *Anterior Abdominal Vein* †, corresponding to the similarly-named vein in Lacertilia, is a single small vein arising at

* According to Schlemm (35) the hepatic portal vein has only one root, and that arises from the right renal portal vein. This statement is also made in Hoffmann (23), but it should be noted that this author quotes nearly the whole of Schlemm's account of the venous system almost verbatim without indicating in any way that he is so doing. My own investigations confirm those of Jourdain (27) and Hochstetter (20), who describe a double root for this vein in *Tropidonotus*, one part arising from each renal portal vein. The latter author makes a similar statement with regard to *Coluber æsculapii*. Beddard (4 & 3) has also recorded the same arrangement in *Coluber corais*, *Zamenis gemonensis*, and *Ancistrodon piscivorus*. According to Jaquart (26) there are a number of anastomoses between the hepatic portal vein and the right renal portal vein in *Python*. In Gadow's account of *Pelophilus madagascariensis*, quoted by Hoffmann (23), it is stated that there is no connection between the hepatic portal and renal portal veins.

† This vein is especially interesting, as it is subject to considerable variation among the Ophidia. In Lizards, as is well known, it arises by two roots from the renal portal veins, and a similar condition is to be found in some snakes, viz., *Eryx jaculus*, *E. johni*, *Python sebæ*, and *Boa diviniloqua*, Beddard (2, 3, & 4). In other snakes

the posterior end of the fat-body and running forward in it to the level of the spleen, where it passes dorsally and opens into the hepatic portal vein. It is only connected in an indirect way by small anastomosing branches with the renal portal veins. Along its course it receives little twigs from the epigastric vein.

The *Epigastric Vein* lies beside the epigastric artery in the mid-ventral line of the abdominal wall. In the region of the liver it gives off five or six small branches, all of which enter directly into the left side of that body and are not connected with the hepatic portal vein. Behind the liver the epigastric vein is connected by a number of small venules with the anterior abdominal vein. As Beddard (4) has pointed out, this is one of the most constant veins in Snakes, and is single save in *Lioheterodon madagascariensis*, where it is alternately single and double.

The veins in the male are, like the arteries, on the whole very similar to those in the female. Those in front of the heart are precisely similar in both sexes.

The caudal vein bifurcates to form the renal portal veins which, at the level of the cloaca, receive the paired pelvic veins, and in addition, in the male a vein from each corpus cavernosum. The renal portals give rise to the two branches which unite above the gut to form the beginning of the hepatic portal vein and then pass forwards to the kidneys between the vasa deferentia and the ureters. On the kidney they receive no specially marked tributary from the vas deferens to correspond with the one from the oviduct in the female.

Each testis gives off one spermatic vein, whereas in the female there are a number of small ovarian veins, just in front of the corresponding supra-renal body, that of the left side opening into the left efferent renal vein, and that of the right into the post-caval vein.

There is no vessel in the male to correspond with the oviducal sinus, and consequently no branch from it to the supra-renal body. The supra-renal portal supply consists of two intercostal veins, one at each end of that body, which arise from the corresponding side of the vertebral column.

Some variation is to be met with in the position of the union of the two efferent renal veins with regard to the kidneys. The junction may be as much as an inch in front of the right kidney, or, on the other hand, this kidney may overlap the point of union, in which case several small veins bring back the blood from the

it has only a single origin from the left renal portal vein, viz., *Eryx conicus, Eunectes murinus*, and *E. notæus*, Beddard (3). Lastly, it may have no direct connection with the renal portal veins, but only indirect ones by means of anastomosing twigs, viz., *Zamenis gemonensis*, Beddard (2), *Coluber æscula*, and *Tropidonotus natrix*, Hochstetter (20). This last observation I have been able to confirm. Further, the anterior abdominal vein may be partly double throughout, as in *Boa constrictor*, *B. diviniloqua*, *Eryx jaculus*, Beddard (4), and *Python sebæ*, Jaquart (26), or single as in *Zamenis gemonensis, Causus rhombeatus, Eryx johni*, Beddard (2), and *Tropidonotus natrix*.

anterior end of the kidney into the right efferent renal vein. On the whole this distance appears to be greater in the female than in the male.

The remaining vessels of the male, the hepatic portal factors, the anterior abdominal vein, and the epigastric vein correspond in all respects to those of the female.

V. The Vessels of the Head. (Pls. LXXI. & LXXII.)

(A) *Arteries.*

It has been pointed out above that the whole of the blood is brought to the head by the left common carotid, the right common carotid having disappeared early in the course of development. To compensate for this absence of an artery on the right ride we find developed three arterial anastomoses between the two sides of the head. The first lies beneath the medulla oblongata and joins the two internal carotids; the second is situated beneath the fore-brain just in front of the optic chiasma and unites the anterior cerebral and facial carotids; and the third is behind the symphysis of the lower jaw and joins the two external carotids.

The *Left External Carotid* (Carotis externa, Rathke; Arteria inframaxillaris, Schlemm) arises from the common carotid internal to the articulation of the lower jaw and the quadrate bone. It runs forward between the floor of the pharynx and the broad mylohyoideus * muscle, first inwards towards the tongue sheath and then outwards to the inner side of the mandible, being accompanied throughout the greater part of its course by its corresponding vein, the glossopharyngeal nerve, and the cutaneous branch of the hypoglossal nerve. At the anterior end of the lower jaw, just a short distance behind the symphysis, the left external carotid anastomoses with its fellow by a well-marked vessel.

The *Right External Carotid* is similar to the left, save that the common carotid from which it originated has disappeared and is represented only by a small branch vessel. It receives its blood-supply partly from the anastomosis just mentioned, and partly from the anastomosis between the internal carotids.

The distribution of the arteries in the dorsal part of the head is the same on both sides, so that the one description will apply equally well to either side.

The *Internal Carotid* (Carotis interna, Rathke; Art. cephalica and Art. carotis communis, Schlemm) starts from the origin of the external carotid and bends in a sharp curve dorsally round the angle of the lower jaw on the inner side of the vagus and hypoglossal nerves. It then passes forward under the columella and along the inner side of the quadrate to a point behind the orbit and above the posterior pterygo-sphenoidalis muscle, where

* The nomenclature of the muscles is that adopted by Hoffmann (23).